OPEN ACCESS
Quick Response Code:
Website: https://wgges.us

Manuscript ID:
IJWGAFES-2026-030217

DOI: 10.5281/zenodo.21544200

DOI Link:
https://doi.org/10.5281/zenodo.21544200

Volume: 3
Issue: 2
February
Year: 2026
E-ISSN: 3066-1552

Submitted: 06 Jan.2026
Revised: 10 Jan.2026
Accepted: 05 Feb. 2026
Published: 28 Feb. 2026

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How to cite this article:
Divekar, A. B. & Chavan, M. N. (2026). Relief Analysis of Daund Tahsil, Pune District, Maharashtra Using Geospatial Technology. International Journal of World Geology, Geography, Agriculture, Forestry and Environment Sciences, 3(2), 78–87. https://doi.org/10.5281/zenodo.21544200

Relief Analysis of Daund Tahsil, Pune District, Maharashtra Using Geospatial Technology

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Abstract

In the present research paper, relief characteristics of Daund Tahsil in Pune District, Maharashtra have been analyzed with the help of Geospatial Technology. Daund Tahsil has a total area of 1360 square kilometers. Daund Tahsil is situated in the eastern part of Pune District in Maharashtra. The study area is a part of the Deccan Basalt Province (DBP) situated on the Deccan plateau physical division of Maharashtra. The maximum area of Daund Tahsil is dominated by plain physiography with gentle slope. The region under study has tropical type of climate highly influenced by the southwest monsoon rainfall. The climate of Daund Tahsil is semi-arid type of climate. According to Koeppen's climatic classification system, the study area of Daund Tahsil experiences 'Aw' (Tropical Savanna) type of climate. Daund Tahsil is situated on the southern bank of Bhima River which is the longest river in Pune District. The Bhima River and its tributaries, namely, Mula-Mutha are the major rivers in Daund Tahsil. An attempt has been made in this research work to analyze the significant characteristics of the terrain such as absolute relief, relative relief, dissection index and slope in order to interpret the erosion vulnerability in the study area. The topography of the study area has been analysed with the help of ASTER GDEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer - Global Digital Elevation Model) and SOI (Survey of India) topographical maps in GIS (Geographical Information System) software Global Mapper version 22. It is inferred that the areas of the Tahsil having higher values of dissection index and high degree of slope indicate that the area is highly prone to soil erosion.

Keywords: *ASTER GDEM, Absolute relief, Relative relief, Dissection index, Slope, Erosion vulnerability, GIS*

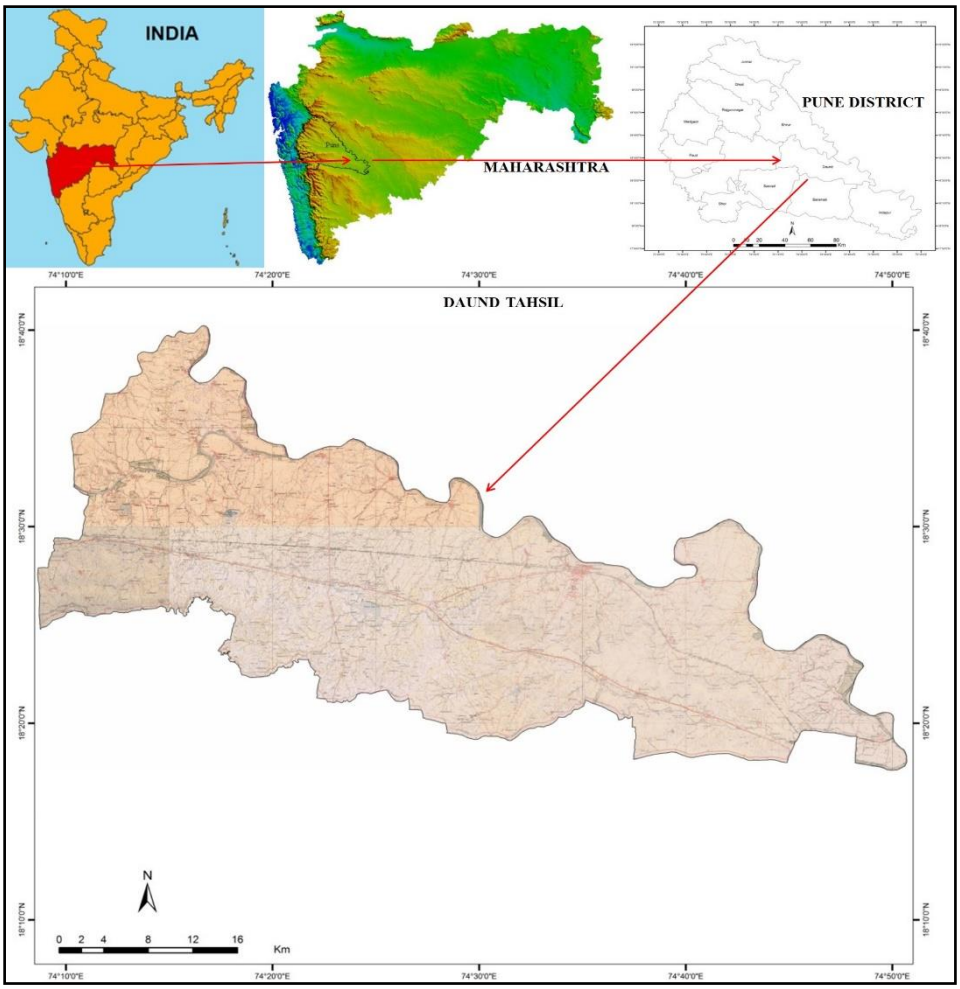
Introduction

The analysis of relief characteristics is a fundamental requirement for interpreting the erosion vulnerability. The topography produced by stream channels, erosion and associated processes of weathering, mass-movement and sheet runoff is extremely complex, both in geometry of the forms and in the interrelations of the processes which produce the forms (Strahler, 1952). The variations in elevation are responsible for variations of relief characteristics such as absolute relief, relative relief, dissection index and slope. Erosion vulnerability studies are very crucial for erosion hazard assessment. The objectives of the present research work are to compute relief parameters in order to understand the relief characteristics and to identify the areas vulnerable to soil erosion in the study area.

Study Area:

Daund Tahsil has a total area of 1360 square kilometers. Daund Tahsil extends from 18° 17' to 18° 40' North latitudes and 74° 08' to 74° 50' East longitudes (Figure 1). Daund Tahsil is situated in the eastern part of Pune District in Maharashtra. The study area is situated on the Deccan plateau and it is geologically a part of the Deccan Basalt Province (DBP). Most of Daund Tahsil has plain physiography and gentle slope. The region under study has tropical type semi-arid climate. According to Koeppen's climatic classification scheme, Daund Tahsil experiences 'Aw' (Tropical Savanna) type of climate. Daund Tahsil is situated on the southern bank of Bhima River which is the longest river in Pune District. The Bhima River and its tributaries, namely, Mula-Mutha are the major rivers in the study area. The soils are mostly fine textured and well drained black soils and medium textured in some patches. Moderately shallow to deep soil covers the maximum area of Daund Tahsil. Deep black soil is found along the low-lying areas of Bhima and Mula-Mutha rivers. This soil is well drained clayey that supports crops such as sugarcane, jowar, bajra, groundnut and onion. This soil is suitable for cultivation of crops when supplemented by irrigation. In Daund Tahsil, the type of natural vegetation is tropical dry deciduous, except along river Bhima which is mixed deciduous vegetation.

Figure 1: Location Map of the Study Area



Database and Methodology:

The following data sources have been used for the relief analysis of Daund Tahsil:

(i) Topographical maps: SOI (Survey of India) Topographical Maps (1:50,000 map scale) have been used as base maps. Survey of India Toposheet Index Numbers: 47 J/2, 47 J/3, 47 J/6, 47 J/7, 47 J/10, 47 J/11 and 47 J/15, covering Daund Tahsil, have been georeferenced in GIS software Global Mapper version 22 and mosaiced together. The georeferencing of the base map has been performed in Global Mapper Software version 22. The stream network, contours, streams, etc. have been digitized using SOI Toposheets.

(ii) DEM: The ASTER GDEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer - Global Digital Elevation Model) data of the Daund Tahsil area having a spatial resolution of 30 meters (Figure 2) has been used for the preparation of slope (%) map.

(iii) GPS Data: The entire study area was tracked with the help of GPS (Global Positioning System) device for ground truthing purpose. A field survey in the study area revealed the scope for research and studying variations in relief and topography.

Methodology:

In order to determine the relief characteristics of the study area, SOI topographical maps of 1:50,000 map scale with a contour interval of 20 meters and ASTER GDEM of the study area having 30 meters resolution have been used. The study area was digitized and demarcated on georeferenced and mosaiced SOI Toposheets in the GIS software – Global Mapper (Version 22). The entire study area was divided into grid cells of 1 km x 1 km dimension with a centroid for every grid cell. The absolute relief values have been computed for each map unit (grid cell) by determining the maximum elevation of contour or spot height from the SOI topographical map. Similarly, the relative relief values have been computed for each map unit (grid cell) by determining the difference between the maximum and minimum elevation of contours or spot heights from the SOI topographical map. Dissection index values in percentage have been computed for every grid cell by dividing relative relief with absolute relief and multiplying it with 100. After computing all the values for each grid cell, the respective centroids are assigned these values. Thematic maps showing absolute relief, relative relief and dissection index have been prepared in Surfer Software (Version 10) by applying the technique of spatial interpolation. Slope map was generated using a grid-based DEM (Digital Elevation Model). The final output maps were prepared using Arc GIS Software (Version 10.3). All the maps showing relief characteristics have been interpreted.

Results and Findings:

Daund Tahsil is a part of the Deccan Basalt Province (DBP). The study area is situated on the Upper Maharashtra Plateau physiographic unit. The maximum area in the study region has plain physiography. Bhima river and its tributaries Mula-Mutha are the major rivers in the study region. The northern part of Daund Tahsil along the Bhima river bank has low relief as compared to the southern part of the Tahsil. The entire study area is nearly flat with fewer variations in relief. The southern boundary of Daund tahsil is demarcated by a small hill range running in east-west direction. There are numerous isolated residual hills in the study area. A considerable area of Daund tahsil is covered by moderately shallow to deep soils which are well drained and clayey in texture on gently sloping lands with few mesas and buttes. The average elevation of the study area is about 555 meters above the mean sea level. The elevation in Daund tahsil varies from as low as 489 meters to as high as 890 meters. There are few peaks in the southwestern region of the study area viz. peak on which Dhavaleshwar temple is situated, Manjar Tok, Sulki Tok etc. The highest elevation is 890 meters (trigonometric station) at Dhavaleshwar temple in Dalimb village, which is situated in the southwestern region of the study area. While the minimum elevation is 489 meters (spot elevation) on the right bank of Bhima river near Rajegaon village, which is situated in the eastern region of the study area. The elevation is less than 550 meters in the maximum area of the study region i.e. in the northern region and the southeastern region which is along the Bhima river. In the southern and southwestern regions of the study area, the elevation is greater than 600 meters (Figure 2 and 3).

Figure 2: Daund Tahsil – DEM (Digital Elevation Model)

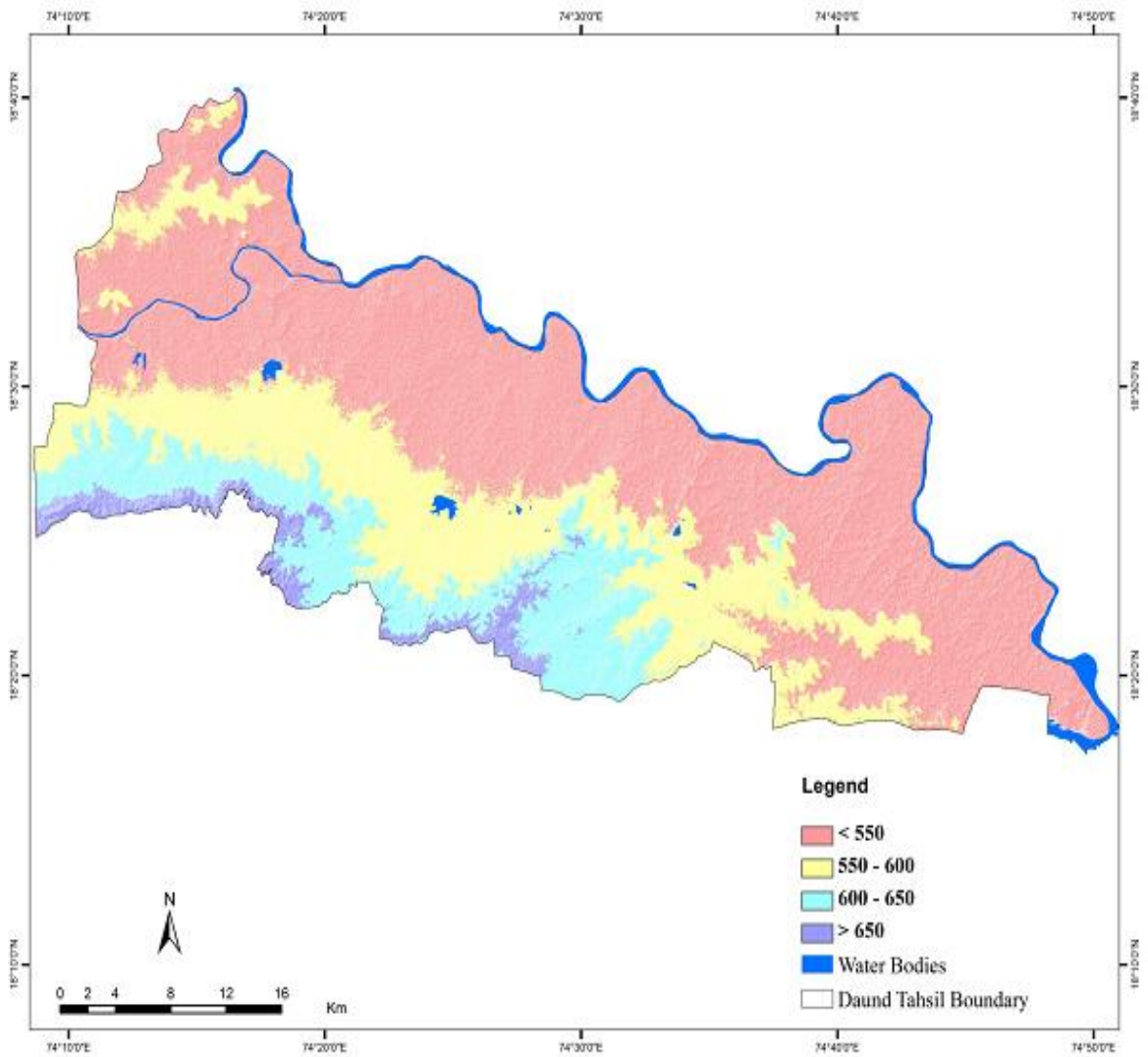
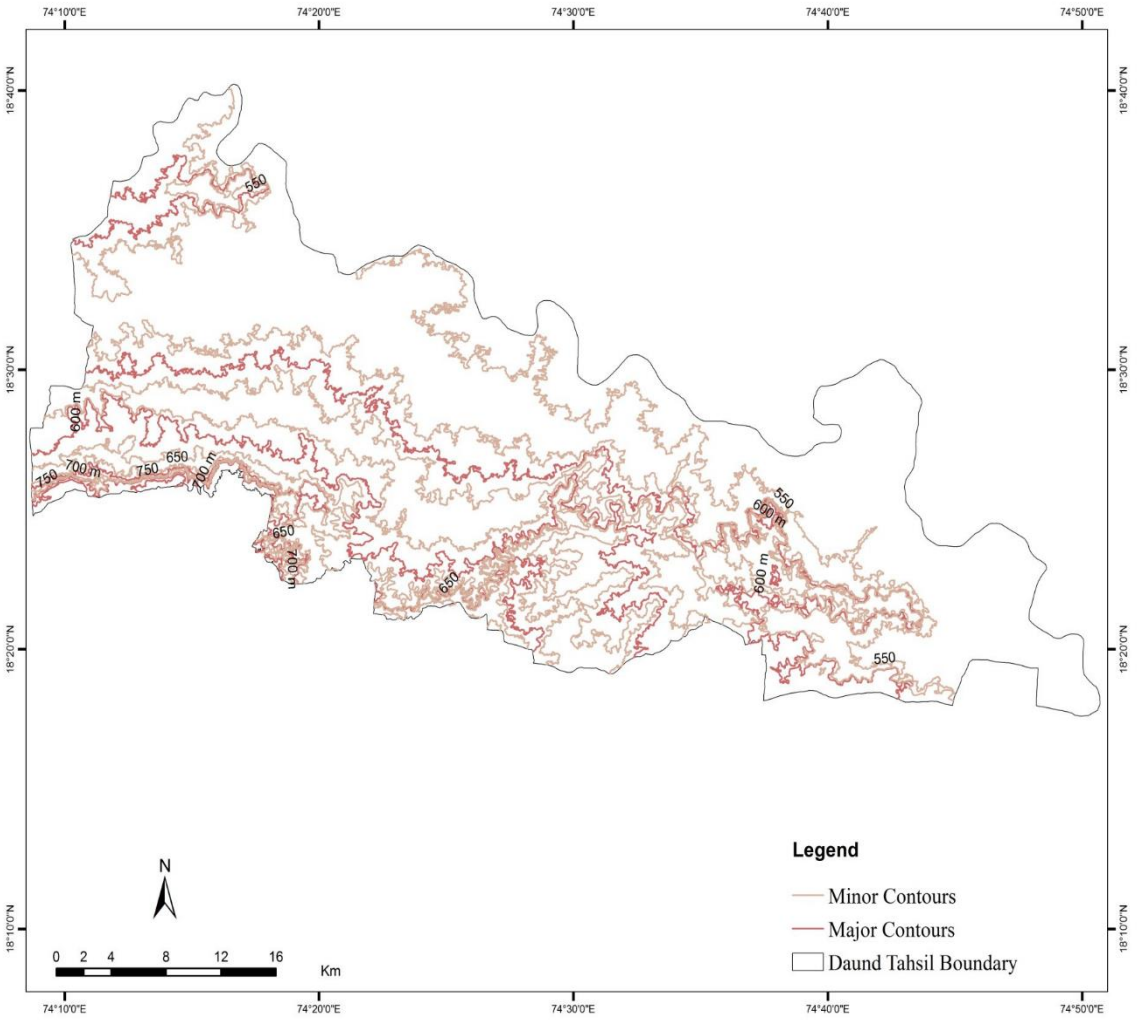
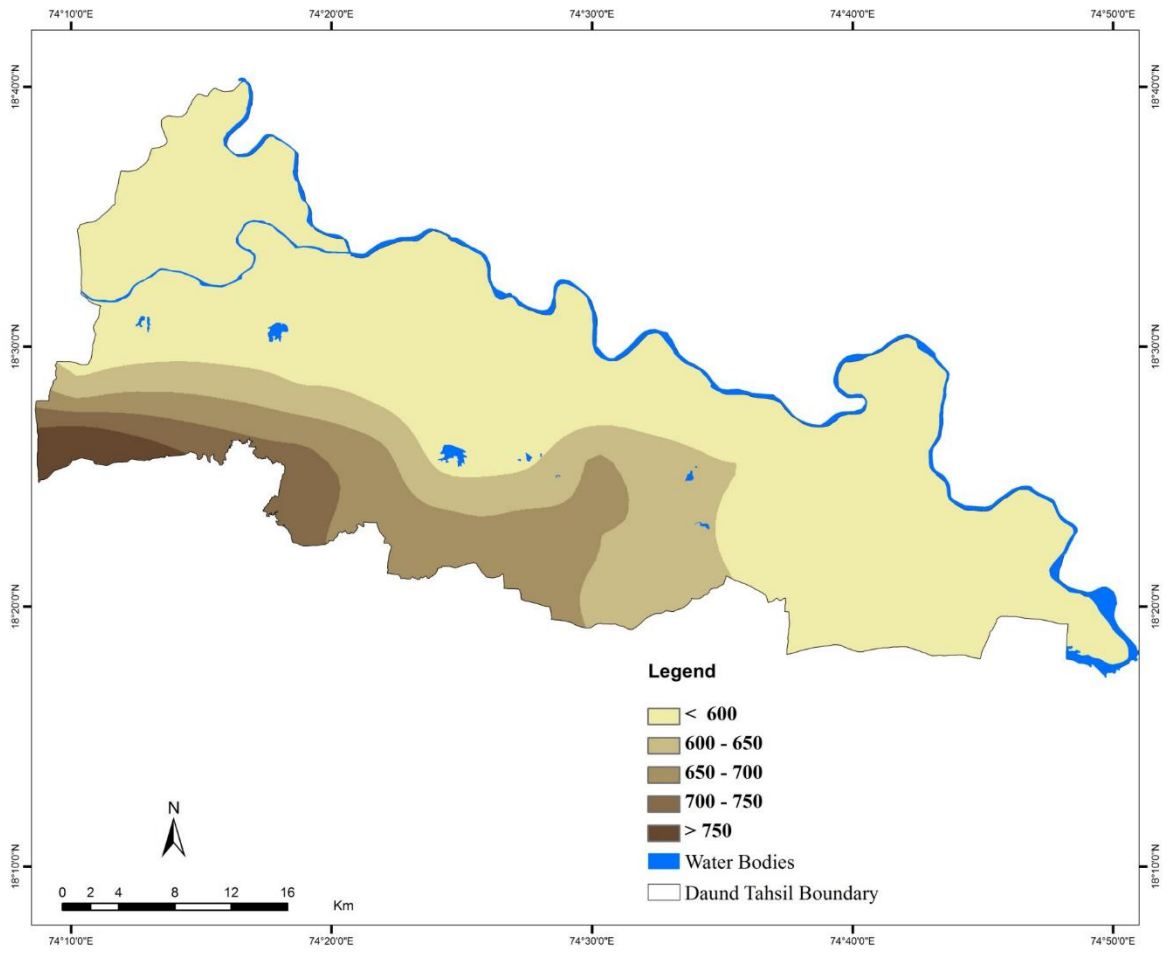


Figure 3: Daund Tahsil – Contour Map



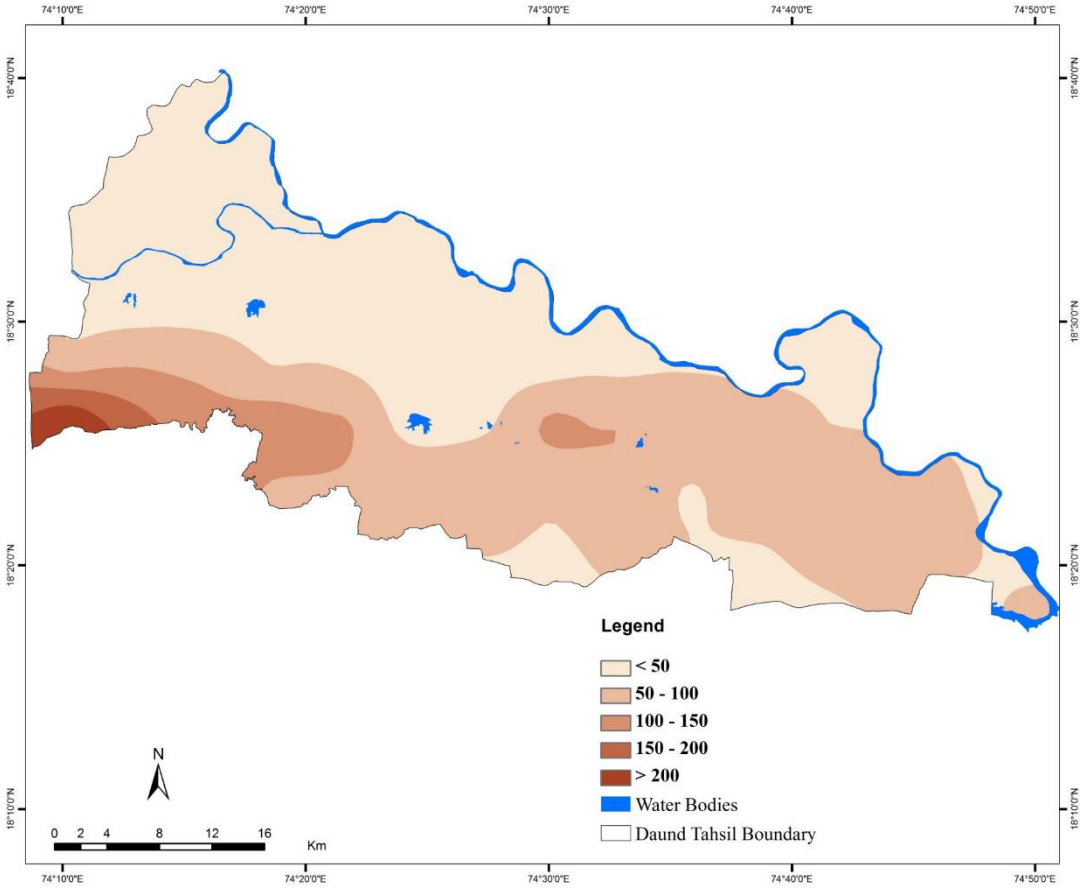
Absolute Relief: The term absolute relief refers to the maximum elevation within a unit area. The absolute relief map provides basic ideas about the pattern of distribution of relief over the study region. It has been observed that the absolute relief increases from the valley bottom to the ridge region. High values of absolute relief are noticed mainly in the mountainous region in the south western marginal area of Daund tahsil. While lower values of absolute relief are noticed in the plains along Bhima river. The absolute relief is higher i.e. more than 700 meters in the south western region and it is lower i.e. less than 600 meters in the northern, eastern and southeastern regions of the study area. The absolute relief is moderate i.e. between 600 to 700 meters in the southern and central regions of the study area (Figure 4).

Figure 4: Daund Tahsil – Absolute Relief



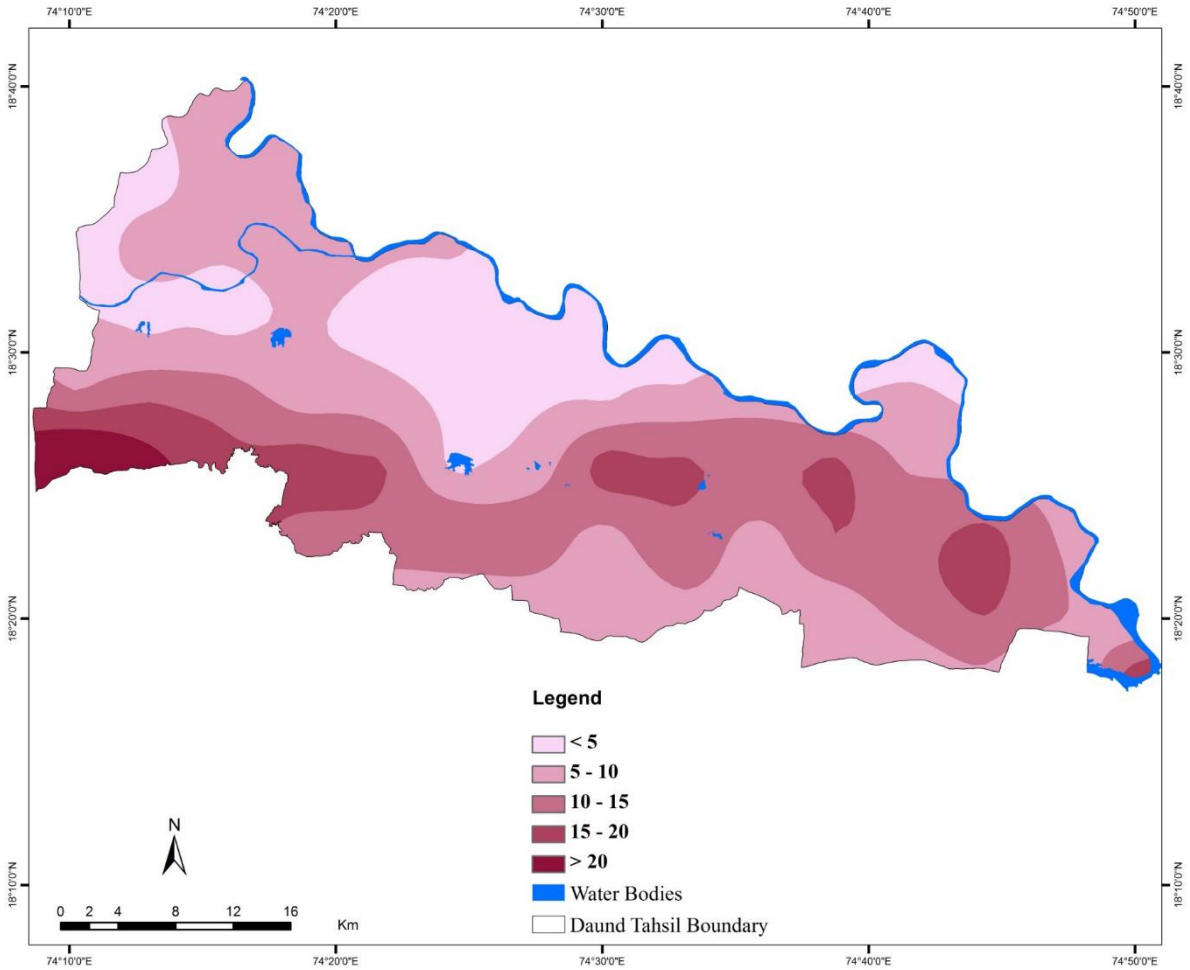
Relative Relief: Relative relief gives an idea about the local relief. It is the difference between the highest and the lowest elevations in a unit area. It is one of the most important parameters of the relief characteristics of an area computed without considering sea level (Singh, 1992) and it is used for the overall assessment of morphological characteristics of terrain and degree of dissection. The relative relief is higher i.e. more than 100 meters in the south western region and one patch in the central region. These areas having high relative relief values are highly prone to erosion. It is lower i.e. less than 50 meters in the northern, southeastern and some patches of southern region of the study area. The relative relief is moderate i.e. between 50 to 100 meters in the eastern and central regions of the study area (Figure 5).

Figure 5: Daund Tahsil – Relative Relief



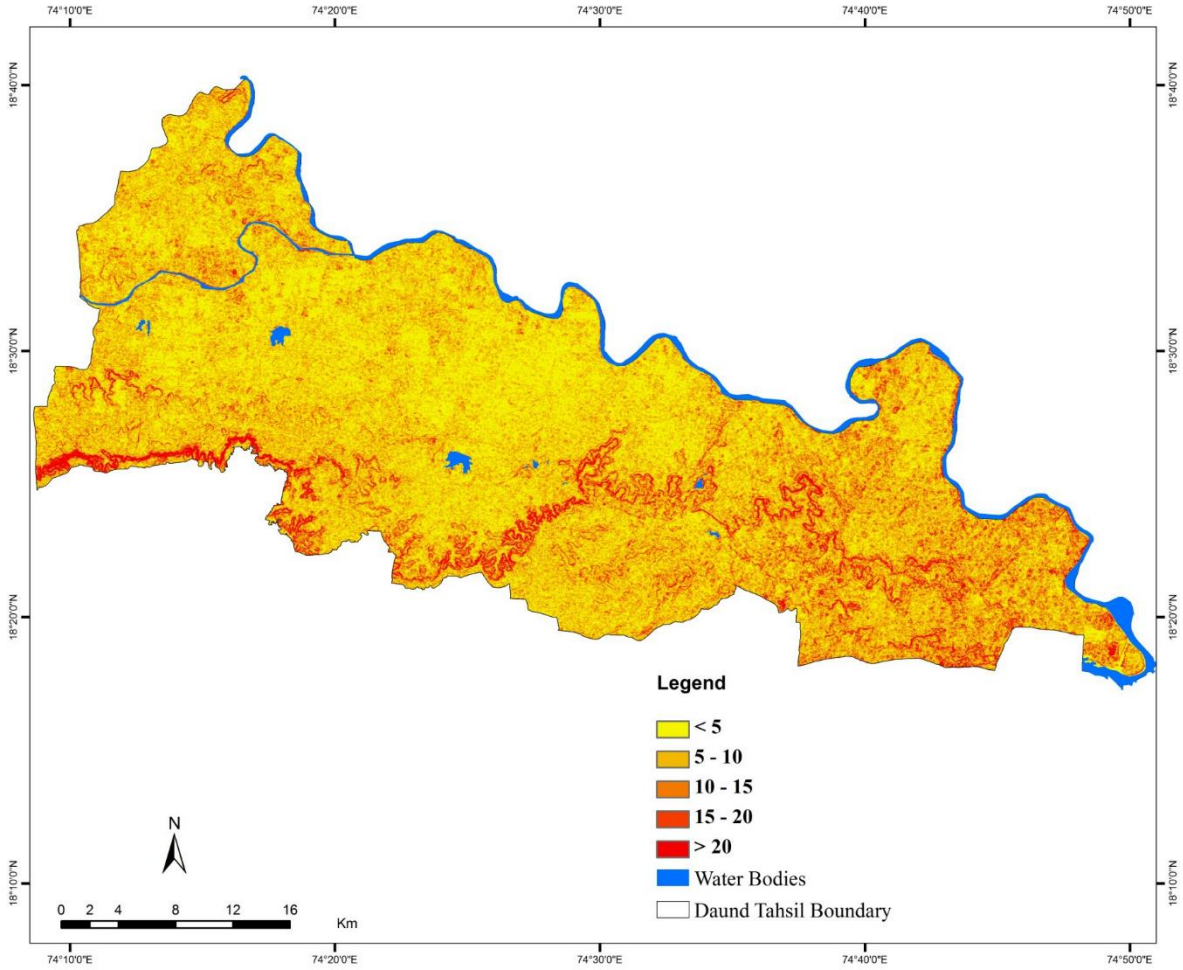
Dissection Index: The dissection index is the ratio of relative relief to absolute relief of a unit area. It is an indicator of the dissection of terrain. It is an important morphometric indicator of the nature and magnitude of dissection of terrain (Singh, 2000). The values of dissection index vary from 0 (complete absence of dissection) to 1 (vertical cliff at sea level). Dissection index values are converted to percentage values by multiplying with 100. Low dissection index values correspond to subdued relief or old stage of cycle of erosion and with low relative relief. The areas having high dissection index values indicate high relative relief where the slope of the land is relatively steep. The dissection index is higher i.e. more than 15 percent in the south western region and few patches in the central and eastern regions. This class indicates areas prone to high rate of erosion. It is lower i.e. less than 5 percent in the northern and northwestern regions of the study area. The relative relief is moderate i.e. between 5 to 15 percent in the central, eastern and some part of western regions of the study area (Figure 6).

Figure 6: Daund Tahsil – Dissection Index (%)



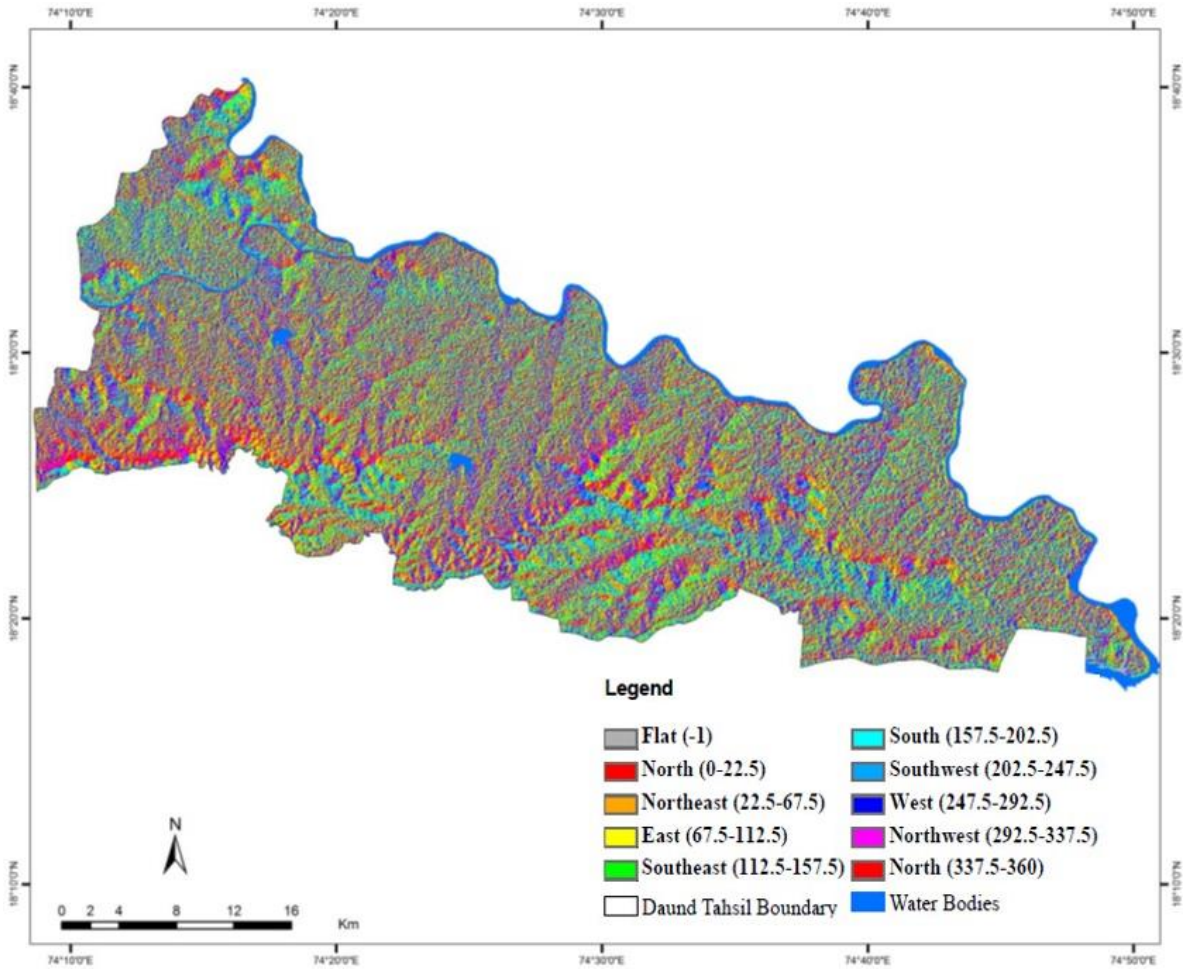
Slope: Slope is one of the most important factors causing erosion and the intensity of erosion increases with high amount of rainfall and deforestation. Slope is the vertical inclination between the hill top and valley bottom. It explained by the horizontal spacing of the contours. In general, closely spaced contours represent steeper slopes and widely spaced contours exhibit gentler slopes. The degree of slope controls the amount of surface runoff, velocity of flow of river as well as the intensity of the processes of erosion, transportation and deposition. Thus, it plays crucial role in landform development (Sinha, 1994). The average slope map shows the distribution of various slope classes in an area. The values of the slope angles derived from ASTER GDEM. The areas where degree of slope is high are highly vulnerable to erosion. The general slope of Daund Tahsil is from south to north along the right bank of Bhima river as the elevation decreases from south towards north. The southwestern region of the study area has steeper slope (more than 20 percent) (Figure 7).

Figure 7: Daund Tahsil – Slope (%)



Aspect: The values from the aspect map indicate the compass directions that slopes face. The slope in the southwestern region of the Daund Tahsil has a north to north-westerly aspect i.e. north and northwest-facing slopes (Figure 8).

Figure 8: Daund Tahsil – Aspect



Conclusion:

The analysis of relief characteristics of Daund Tahsil reveals a landscape primarily characterized by a gently sloping, plain topography consistent with its location in the Deccan Basalt Province. Situated on the southern bank of the Bhima River, the region features an average elevation of approximately 555 meters, with a distinct topographical gradient from a higher elevation in the southwest (exceeding 890 meters at the southern hill range) to a lower elevation in the north and southeast along the riverbank. The general landscape slopes from south to north which means that the terrain is generally sloping from the higher southern ridges towards the northern Bhima River valley. Steep slopes (over 20%) are located in the southwest, featuring north to north-westerly aspects.

The absolute relief or highest elevations (>700 meters) are concentrated in the southwestern margin, while the northern and eastern plains exhibit lower relief (<600 meters). High relative relief (>100 meters) and high dissection indices (>15%) are concentrated in the southwestern and isolated central patches, indicating areas prone to higher erosion. Conversely, the majority of the region has low to moderate dissection, indicating a subdued terrain. The analysis of the dissection index and slope indicates that the southwestern and specific central patches are the most geologically active and prone to erosion. These areas feature slopes exceeding 20% and dissection indices above 15%, contrasting sharply with the stable, low-dissection plains of the north and northwest.

The analysis of relief characteristics especially the dissection index values and slope values is highly significant for the identification of the areas vulnerable to erosion in the Daund Tahsil. Highly erosion prone areas are those which have high dissection index values and high degree of slope. The high dissection index values correspond to the high degree of slope. In summary, Daund Tahsil is predominantly a plain region with moderate to low dissection, except for the hilly terrain in the southwest. The integration of ASTER GDEM data, SOI Toposheets, and GIS techniques highlights a distinct spatial variation in relief, with the southwestern region being the most rugged, while the vast northern area is low-lying plain suited for agriculture. The study successfully demarcates the Tahsil into distinct zones: a rugged, high-relief southwestern upland with north-to-northwesterly aspects, and a vast, fertile northern plain that defines the region's primary physical and economic character.

Acknowledgment

The authors express their sincere gratitude to the Survey of India for providing the topographical maps used in this research. The authors are also thankful to NASA and the ASTER GDEM project team for making the Digital Elevation Model data available for academic and research purposes.

The authors extend heartfelt thanks to the Department of Geography, Subhash Baburao Kul Arts, Commerce and Science College, Kedgaon, and the Department of Geography, Sir Parashurambhau College, Pune, for providing the necessary academic support and facilities to carry out this research work successfully.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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